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11.0 DRAINAGE AND EROSION CONTROL

11.1 INTRODUCTION

This section contains criteria and procedures for the selection and design of drainage structures and erosion and sediment control measures. Both the temporary and permanent drainage structures and erosion and sediment control measures presented here are those which may be anticipated by the designer and are to be included on the design drawings.

Additional structures and measures, which will be employed in accordance with field conditions, are discussed in this section. It is recognized that field personnel provide designs and measures for unexpected erosion and sedimentation problems that develop during construction and operations. The selection and design of all such structures and measures will conform to the criteria presented here.

Field design practices, specifications and calculations are not included in this section. Design criteria and procedures for embankments, ditch configurations, clearing, bridges, restoration and river, stream and wetland crossings are found in other sections of this Technical Information Supplement. Criteria regarding the siting of various facilities are also discussed in other appropriate sections of this Technical Information Supplement.

All areas to be disturbed during the course of construction will be evaluated to determine any necessary erosion or sediment control measures. The control measures selected will be based on consideration of the following factors: seasonal considerations, duration of disturbance, soil types, grading conditions, drainage patterns, pipeline ditch mode requirements, and the vegetation and habitat types present. The physical and biological characteristics of any nearby surface waters and the net environmental benefit of the control measure, considering the loss of habitat and impact on third party facilities and structures, will also be considered.

11.2 CODES AND CRITERIA

11.2.1 Codes

- United States Code, Title 16 – Conservation (Fish and Wildlife Coordination Act of 1934, as amended)
- Code of Federal Regulations, Title 33 – Navigation and Navigable Waters
- Executive Order 11988 – Floodplain Management
- Code of Federal Regulations, Title 18 – Conservation of Power and Water Resources
- Code of Federal Regulations, Title 40 – Protection of Environment, Part 125 – Criteria and Standards for the National Pollutant Discharge Elimination System
- Code of Federal Regulations, Title 43 – Public Lands: Interior
- Federal Energy Regulatory Commission conditional certificate of public convenience and necessity, issued on December 16, 1977, as such is finalized

- Alaska Statutes, Title 16 – Fish and Game, Chapter 16.05 – Fish and Game Code
- Alaska Statutes, Title 16 – Fish and Game, Chapter 16.10 – Fisheries and Fishing Regulations
- Alaska Statutes, Title 46 – Water, Air, Energy and Environmental Conservation, Chapter 46.03 - Environmental Conservation
- Alaska Statutes, Title 46 – Water, Air, Energy and Environmental Conservation, Chapter 46.15 - Water Use Act
- Alaska Administrative Code, Title 5 – Fish and Game, Chapter 95 – Fish and Game Habitat
- Alaska Administrative Code, Title 18 – Environmental Conservation, Chapter 70 – Water Quality Standards and Chapter 72 – Wastewater Treatment and Disposal
- Federal Right-of-Way Grant for the Alaska Natural Gas Transportation System Alaska Segment, Serial No. F-24538 (December 1, 1980), as such may be updated and/or amended from time to time.

11.2.2 Criteria

- Locate and design drainage structures and erosion and sediment control measures so that access for vehicles and equipment required for the construction, operation and maintenance of the gas pipeline will not be impaired.
- Locate and design drainage structures and erosion and sediment control measures to be compatible with existing adjacent structures or crossings of other facilities.
- Minimize hydraulic soil erosion and thermal degradation.
- Minimize sedimentation to comply with the Alaska Water Quality Standards.
- Minimize disturbances to fish and wildlife habitat, wetlands and riparian areas, as well as archaeological sites.
- Minimize visual impact.
- Minimize permanent alterations to existing surface water configurations and hydraulics.
- Avoid areas of known icing problems, except where other design considerations do not permit.
- Prevent permanent obstructions to small craft passage in navigable waters.
- Assure free passage and movement of fish in all fish bearing streams.
- At sites where surface stripping is required, organic material will be segregated and stockpiled for rehabilitation purposes.
- Where infiltration galleries or surface water sources are used, adequate flow will be maintained to support indigenous aquatic life. Water intake structures will be

designed, operated and maintained to prevent fish entrapment, entrainment, or injury, unless specifically exempted by the Alaska Department of Fish and Game.

- Determine the design frequency flood, which is based on a correlation of drainage area with corresponding frequency floods at the 25 percent confidence level for estimating runoff, as follows:
  - Fifty-year frequency floods will be used in design of permanent structures.
  - Five-year frequency floods will be used in design of temporary structures. If there are structures downstream that would be adversely impacted by a failure of the gas pipeline structure, a higher discharge will be used in the design.
  - Two-year frequency floods will be used as the project mean annual flood.
- Ensure the design of the gas pipeline drainage structure is compatible with adjacent facilities.
- Design the drainage structures and erosion and sediment control measures assuming steady, uniform conditions for open channel flow.
- Select cross drainage structures for workpads or access roads only when workpad or access road continuity across drainage is required (see Section 9).
- Design cross drainage structures to minimize overtopping the embankment by collected sheet flow (see Section 11.3.2.2, Sheet Flow, below).
- Provide cross drainage structures to convey collected sheet flow across the workpad/ditch or access road as often as practical to minimize:
  - Downslope dewatering of wetlands.
  - Permanent upslope ponding particularly on thaw unstable soils.
  - Excessive concentrations of flows.
- Select cross drainage structures as follows:
  - Culverts are the preferred cross drainage structure during construction.
  - Low water crossings (LWC) (see Section 11.3.3.3, Low Water Crossing (LWC) Design, below) are preferred where icing or debris problems are anticipated.
  - Bridges are preferred only where culverts and LWC are not acceptable and access is required.
- Design culverts based on the following:
  - To accommodate the efficient passage and movement of fish, both upstream and downstream, at all flows up to and including the mean annual seasonal flood design discharge with a two-day duration for the specific time of year for the weakest fish (design fish) present in the waterbody.
  - Place culverts on same gradient as natural stream.
  - Culvert projection must be a minimum of 1 foot at the embankment toe.

  - Culvert diameters will comply with Alaska Department of Fish and Game recommended size for non-fish and fish streams.
- Design LWC based on the following:
  - Any LWC will be designed to accommodate the efficient passage and movement of fish, both upstream and downstream, at all flows up to and including a mean annual flood design discharge with a two-day duration.
  - Only material which resists rutting, prevents erosion and downstream sedimentation and precludes "French-draining" shall be placed in LWCs.
- LWC requiring excavation will not be used over Trans Alaska Pipeline System (TAPS) Fuel Gas Pipeline.
- Use ditch checks, channel liners, or sediment traps where required to control flow velocities, prevent erosion, and trap sediment in constructed ditches.
- Do not locate plunge basins in either designated fish streams or areas of thaw unstable soil.
- Do not locate sediment basins in active stream channels, areas of thaw unstable soils, or areas where the potential impact of the basin exceeds water quality benefits.

11.3 DESIGN PROCEDURES

Structures and other measures required for drainage, erosion and sediment control are divided into the following three categories:

- Drainage structures including:
  - Low water crossings
  - Culverts
  - Bridges
  - Drainage ditches
- Erosion and sediment control measures including:
  - Temporary diversion
  - Fluming
  - Pumping
  - Energy dissipaters
  - Ditch checks
  - Plunge basins and aprons
- Grading to drain
  - Ditches

  - Diversion levees
  - Water bars
  - Permanent vegetation
  - Letdown structures
  - Channel liners
  - Temporary vegetation and covers
- Mechanical compaction
  - Percolation ponds
  - Vegetative filter areas
  - Sediment traps
  - Silt fences
  - Sediment filters
  - Sediment basins
  - Recycle ponds
- Thermal erosion control measures including:
- Controlled ablation
  - Gravel buttresses
  - Insulated thermal blankets
  - Channel liners

11.3.1 Input Data Requirements for Selection and Design of Drainage, Erosion or Sediment Control Structures and Measures

- Access Requirements

  The volume and type of traffic will be considered in determining the need for and selection of cross drainage structures.

- Topographic Data

  Topographic drawings, maps and aerial imagery will be used to determine the hydrologic characteristics of the drainage basin.

- Survey Data

  Detailed elevations, slopes, cross sections, profiles, stream alignment and flow depth will be provided by field surveys. High water marks as well as the location of existing or potential debris or aufeis problem areas will be provided by field reconnaissance.

- Hydrologic Data

  Runoff data will be required for each basin for the specified frequency flood.

- Geotechnical Data

  Soil type and soil erosion classification (SEC) will be required to determine structure types and protective measures. The thermal state and expected thaw strain of the natural soil encountered will be necessary to select the appropriate design and insulation requirements. The SEC classification methodology will be used for design of drainage ditch and diversion levee side slopes and allowable flow velocity.

- Scheduling

  Design in consideration of construction timing is important for some aspects of drainage and erosion control. Seasonal effects will be considered in the design process.

- Environmental Data

  Information that will be required on any potentially affected streams will include water quality, habitat, fish presence, and their seasonal stream use. Water quality information to be considered will include natural conditions, seasonal variations and existing uses. This information can be obtained from the Environmental Master Guide (EMG), as may be updated or amended from the original. Also to be considered will be natural sediment deposition patterns and streambed characteristics (see Section 16).

- Existing Facilities

  Information will be required on facilities adjacent to the gas pipeline. This information will include hydrologic data used for design of such facilities (see Section 16).

- Geometry and Embankment Thickness

  The construction zone geometry, workpad cross-section and embankment thickness will be used to design the structure (see Section 9).

11.3.2 Hydraulic Design

11.3.2.1 Open Channel Flow

Manning's equations are typically used for discharge and velocity calculations.

11.3.2.2 Sheet Flow

Sheet flow occurs where no well-defined drainage channels exist and the ground is sloped predominantly in one direction. Sheet flow will be mitigated as described below.

When next to the Dalton Highway, match workpad cross drainage locations to the existing highway cross drainage locations.

When downhill from (generally within 500 feet) but not touching adjacent structures (primarily embankments), match access road and workpad cross drainage locations to drainage patterns established and controlled by the uphill structure. Provide additional structures if necessary to keep the gas pipeline embankment from being topped by ponded water. Upon an analysis of impact to the adjacent structure or facility, the 500 feet dimension may require modification.

When uphill from (generally within 500 feet) but not touching adjacent structures, locate access road and workpad drainage structures to collect and direct sheet flow to the existing downhill structures, unless more frequent spacing is deemed necessary. Provide additional structures if necessary to keep the gas pipeline embankment from being topped by ponded water. Upon an analysis of impact to the adjacent structure or facility, the 500 feet dimension may require modification.

The 500 feet distance has been selected as a guideline for the designer or field engineer and it should be considered a minimum. Other factors such as third party adjacent facilities, environmental concerns, soil thermal conditions, etc. have to be taken into consideration (even if they are outside the 500 feet distance) for any potential adverse impact that may occur due to construction of the gas pipeline.

When not immediately adjacent to existing structures (generally greater than 500 feet away) place cross drainage structures at locations that the center line profile show to be low points and where the embankment would be topped by ponding. These steps will be followed when determining spacing of cross drainage structures. Upon an analysis of impact to the adjacent structure or facility, the 500' dimension may require modification.

- Levees and ditches may be used if necessary to divert flows; however, they will not be used instead of a cross drainage if cross drainage spacing were to exceed 300 feet.
- In wetlands, maximum spacing for culverts will be 500 feet, but closer spacing will be used if conditions dictate.
- To prevent gas pipeline embankments from causing excessive concentration of flows, add additional cross drainage structures as determined on a site-specific basis if the area has:
  - Historical thermokarst problems.
  - Cross-slopes, within 500 feet downhill, averaging greater than 10 percent with moderate or high excess ice content soils.
  - Local topography and vegetative features, which indicate sheet flow has caused erosion in the past. The primary indicator is well-defined gullies that have no specific upstream feed source other than sheet flow. Vegetation covers in the gullies, particularly trees correcting upward growth to accommodate soil creep, are indicators of the relative stability of the gully.
- Ditches, channels or "half round" culverts may be used to convey collected sheet flow downstream from the workpad or road to an existing streambed.

11.3.3 Drainage Structure Design

11.3.3.1 Cross Drainage Structure Selection for Workpad and Access Roads (Traffic Structures)

Cross drainage traffic structures will be selected only where workpad or access road continuity is required. No structure will be required where a major river is crossed, or where sufficient access is provided by the Dalton or Elliott Highways. The procedure for selecting cross drainage structures is summarized below:

- Culverts will be preferred over other structures during construction and will be considered where:
  - Culverts can accommodate the estimated discharge.
  - Deeply incised drainage paths exist.
  - Significant icing or debris problems are not anticipated.
  - High traffic volumes will occur.
  - Fish passage can be accommodated, ensuring both up-stream and downstream migrations.
- LWC will be preferred to other structures during operations and maintenance and will be considered for use during construction where icing or debris problems are anticipated.
- The flow depth and velocity for design floods will be considered for traffic safety requirements.

11.3.3.2 Stream, Structure, and Pipe Ditch Protection

Any changes to or disturbances of natural streams may result in channel and bank migration (See Section 16). Accordingly, channel and bank protection may be required at the inlet or outlet of structures wherever the design flood velocity exceeds the maximum allowable velocity of the natural stream bed material. Channel protection will be designed on a site-specific basis to follow natural stream configurations and will consist of:

- Riprap, which will be designed in conformance with Section 16.
- Plunge basins, which will be designed to dissipate the energy of water flowing from the outlets of drainage structures.

Flow over the gas pipeline ditch will normally be handled as part of the upstream or downstream protection when such protection is required. Protection in the form of a low permeability blanket or channel lining will be provided at all locations where such a flow path has been identified. Ditch plugs will be installed as required (see Section 13).

Flow in the open gas pipeline ditch may be controlled by the use of temporary ditch plugs and by pumping out the sediment-laden water into a sedimentation basin or onto a vegetated area. Discharge of this water is discussed in Section 11.

11.3.3.3 Low Water Crossing (LWC) Design

LWCs are prepared drainage channels through which vehicular traffic can pass. For design purposes they are assumed to be of trapezoidal cross section. Design of LWCs will proceed as follows:

- Select LWC type, based on the soil erosion classification of streambed material, the thermal stability of soils underlying the embankment and access requirements (see Figures 11-2 through 11-6):
  - Type I for rock, cobbles or clean sand and gravel.
  - Type II for dirty sand and gravel.
  - Type III for silty and clayey soils.
  - Type IV for all soils in areas where thermally designed embankment is required.
  - Types IA, IIA, IIIA and IVA for areas where access through a fish stream is required during construction. LWCs designated by the letter “A” are modified to include a temporary culvert. The temporary culvert will be removed after the gas pipeline construction is completed. The LWC will remain to accommodate operations and maintenance traffic.
- Survey a representative elevation of the natural stream (the deepest portion of the channel) both upstream and downstream, and use the information to determine the natural grade of the stream. The LWC will be installed so that this natural grade is not exceeded at the top surface of material placed in the bottom of the crossing.
- Determine the design flows.
- Using Manning's equation, determine flow velocities and depth for appropriate design flows and perform the following checks:
  - Verify that material in LWC channel will not scour.
  - Verify that work pad or embankment material will be stable.
  - Check for upstream or downstream channel protection.
  - Check for compatibility with adjacent drainage structures as well as adjacent third party facilities. In addition to appropriate project design flows, third party design flows will be considered.
  - Verify that the maximum allowable average velocity enables fish passage, for designated fish streams only.
- Part of an LWC is a pipe layer crossing (PLC) through which tracked equipment may pass during pipeline construction. The PLC reduces the width of the improved drive lane.
- Only material which resists rutting, prevents erosion and downstream sedimentation and precludes “French-draining” shall be placed in LWCs.

- LWCs will be constructed to match the existing stream geometry (width and depth) as closely as possible. The bottom profile shall be V-notched or sufficiently narrow at the thalweg (deepest part of the stream channel) to confine the water to a depth that will ensure fish passage during low flows.
- The structure will be designed, installed and maintained to accommodate the efficient passage and movement of fish, both upstream and downstream, at all flows up to and including a mean annual flood design discharge with a two-day duration. Note that fish passage design flow is not the same as the culvert design or flood flow. The flood flow is the maximum anticipated stream discharge that the structure must safely accommodate during its design life. The fish passage design flood is the maximum stream discharge at which fish passage must be assured. The Alaska Department of Fish and Game (ADF&G) has defined the fish passage design flood as the mean annual, two-day duration flood for the specific time of year that the design fish is migrating upstream. The ADF&G is responsible for identifying the design fish and the seasonal period for calculation of the fish passage design flood.
- Alteration to streambanks will be minimized and restricted to that necessary for the stream crossing. Disturbed streambanks shall be immediately stabilized to prevent erosion and sedimentation of the stream.
- If any of the above checks are not met, either alternate structures or site-specific designs will be considered.

11.3.3.4 Culvert Design

Culverts will consist of corrugated metal pipes, which will be buried under an embankment. All or part of the gas pipeline related vehicular traffic must pass this embankment. The design of culverts will proceed as follows:

- Select culvert length:
  - Use minimum length practical.
  - Under workpad, place culvert only under traffic lane, except where channels prohibit crossing by pipe-laying equipment.
- Determine the design flows based on whether the culvert will be required as a permanent or temporary structure (see Section 3).
- Select the culvert slope, elevation, and skew to approximate the existing natural stream channel as closely as practical.
- Determine trial culvert size.
- Determine if trial culvert operates under inlet or outlet control.
- Determine the appropriate design culvert size.
- Determine the flow velocity and depth for the design flood and perform the following checks:

- Check depth and velocity for design flood to ensure that workpad or embankment material will be stable.
- Check velocity with maximum allowable velocity to ensure fish passage.
- In a multiple culvert installation, fish passage must be provided through at least one culvert, usually the main thalweg culvert.
- Check for upstream or downstream channel protection where design flood velocities exceed the maximum allowable velocity of the native stream bed material.
- Check minimum cover requirements. Multiple culverts or pipe-arch culverts may be required to provide minimum cover.
- Check for thermal stability. Insulated culverts may be required where expected thaw settlement over the design life exceeds one foot or where thermally designed embankment is required.
- Check for areas of known or expected icing or aufeis problems.
- Check for areas of known or expected debris problems.
- Check for compatibility with adjacent drainage structures as well as other adjacent third party facilities. In addition to appropriate project design flows, third party design flows will be considered.

• The culvert will be designed, installed, and maintained to accommodate the efficient passage and movement of fish, both upstream and downstream, at all flows up to and including a mean annual seasonal flood design discharge with a two-day duration for the specific time of year that the weakest swimming fish (design fish) present in the waterbody must be assured passage. Note that fish passage design flow is not the same as the culvert design or flood flow. The flood flow is the maximum anticipated stream discharge that the structure must safely accommodate during its design life. The fish passage design flood is the maximum stream discharge at which fish passage must be assured. The ADF&G has defined the fish passage design flood as the mean annual, two-day duration flood for the specific time of year that the design fish is migrating upstream. The ADF&G is responsible for identifying the design fish and the seasonal period for calculation of the fish passage design flood.

• Alterations of streambanks will be minimized and restricted to that necessary for the stream crossing. Disturbed streambanks shall be immediately stabilized to prevent erosion and sedimentation of the stream.

• If any of the above checks are not met, either alternate structures, or special site-specific designs will be considered.

11.3.3.5 Traffic Bridge Design

Generally, bridges will be either of a panel or mat type, so that it can be erected for most spans and loadings. Bridges will be erected according to specifications provided (see Section 14). Mud sills or cribs will be placed or driven as needed.

The procedure to determine stream flow for bridge design will be as follows:

- Determine design flow.
- Determine the existing flow depth, velocity, and waterway cross section for the design flood. If the bridge abutment encroaches on the stream during the design flood, methods found in the U.S. Department of Transportation's Hydraulics of Bridge Waterways Hydraulic Design Series will be used.
- The bridge will be designed, installed, and maintained to accommodate the efficient passage and movement of fish, both upstream and downstream, at all flows up to and including a mean annual seasonal flood design discharge with a two-day duration for the specific time of year that the weakest swimming fish (design fish) present in the waterbody must be assured passage. Note: Fish passage design flow is not the same as the culvert design or flood flow. The flood flow is the maximum anticipated stream discharge that the structure must safely accommodate during its design life. The fish passage design flood is the maximum stream discharge at which fish passage must be assured. The Alaska Department of Fish and Game has defined the fish passage design flood as the mean annual, two-day duration flood for the specific time of year that the design fish is migrating upstream. The ADF&G is responsible for identifying the design fish and the seasonal period for calculation of the fish passage design flood.
- Structural design of bridges is discussed in Section 14.
- Check for compatibility of adjacent third party facilities. In addition to appropriate project design flows, third party design flows will be used in impact assessment. See Section 14 for additional third party facility considerations.

11.3.3.6 Drainage Ditches

Concentration of flows will be avoided, where possible, but will be required in some locations.

For design purposes, drainage ditches will be assumed to have trapezoidal or triangular cross sections with variable dimensions. Ditches will be designed as follows:

- Drainage ditches are preferred to diversion levees. Select ditches where:
  - Flows must be carried through or around fill, cut, through-cut or cut/fill sections or embankments.
  - Flows must be carried through or around civil facilities such as material and disposal sites.
  - Sheet flow to be intercepted on thaw unstable cross slopes.
  - Drainages are to be intercepted and diverted.
- Use site-specific design if concentration of flows over thermally unstable soils is required.

- Determine the design flows based on whether the drainage ditches will be required as permanent or temporary structures.
- Determine the ditch side slopes based on the soil erosion classification.
- Determine the ditch length and slope based on the site reconnaissance.
- Determine the ditch shape and then the design flow depth.
- Determine the flow velocity and perform the following checks:
  - Check for necessity of channel liners where design flood velocities exceed the maximum allowable velocity of the soil.
  - Check for thermal stability. Insulation or alternate structures may be required to prevent thawing of the permafrost.
  - Check for areas of known icing or aufeis problems.
  - Check for compatibility with adjacent drainage structures as well as other adjacent third party facilities. In addition to appropriate project design flows, third party design flows will be considered.
- If any of the above conditions are not met, either alternate structures or site-specific designs will be considered.

11.3.3.7 Ice and Aufeis Control

All designs for the control of icing or aufeis will be on a site-specific basis. Such designs will consider the use of:

- Thaw pipes or thaw wires.
- Larger drainage structures.
- Structures that cannot be easily blocked by aufeis (i.e., LWCs).
- Perched relief culverts or modified LWCs.

Structures which are to have ice and aufeis control are those where:

- Adjacent structures within 500 feet have thaw pipes or wires.
- The area has a recorded aufeis history.
- Design analysis indicates that a chilled pipe at a stream crossing may cause aufeis.

11.3.3.8 Debris Control

Accumulation of debris at the drainage structure inlet is a frequent cause of unsatisfactory performance. These accumulations may result in failure of the drainage structure and damage to the embankment.

All designs for the control of debris at the drainage structure inlet will be on a site-specific basis. Such designs will consider:

- Structures that cannot be easily blocked (i.e., LWCs).
- Debris deflectors to divert debris to a storage area where it can be removed.
- Debris rack - a barrier across the stream that stops debris which is too large to go through the structure.
- Debris fins used with large structures to orient the debris to pass through the structure.
- Perched relief culverts or modified LWCs.
- Clear-span bridges.
- Debris control structures in fish bearing streams that do not prohibit fish passage.

Structures to have debris accumulation control are those where:

- Adjacent structures have debris control measures.
- The area has a recorded debris problem.
- Upstream natural erosion processes are rapidly depositing debris and show potential to continue to do so.

11.3.4 Erosion and Sediment Control Design

This section contains information on the erosion and sediment control measures that may be utilized in the final design.

11.3.4.1 Erosion Control

Keep soil loads from entering water or wind by incorporating the following appropriate measure(s):

- Reduce or keep water out of construction zone (temporary diversions, fluming, pumping).
- Slow water velocities to allowable rates (energy dissipaters, ditch checks, plunge basins).
- Keep water from flowing across eroding areas (graded to drain, ditches, levees and water bars).
- Plant permanent or temporary vegetation, place letdown structures, channel liners, or temporary covers, and employ mechanical compaction as required.
- Achieve sedimentation control by removing soil loads from water. Do this by:
  - Filtering soil loads from water using gravelly low areas (percolation ponds).
  - Filtering soil loads from water using vegetative filters.
  - Settling soil loads from water using sediment traps.
  - Filtering soil loads from water using geofabrics (silt fences, sedimentation filters).

Reuse water using recycling ponds.

11.3.4.2 Erosion Control Measures

11.3.4.2.1 Temporary Diversions

Temporary diversions will be selected as the prime method of keeping water out of the construction work area in floodplains and alluvial fans.

Diversion locations will be biologically assessed and not used if flow rechanneling or downstream dewatering has biological impacts on fish spawning or overwintering areas. No diversions will be used if diverted flows would have adverse impacts on third party structures. Naturally occurring and/or existing high water channels are the preferred features to be used to convey the diverted water in river systems. The optimal location for temporary diversions in a braided river system is at a fork where the riffle area at the head of one of the branches provides a relatively coarse material at shallow depths for berm construction and the other branch provides a natural diversion channel. Artificial channels will be designed when no naturally occurring channels exist. As an alternative, in ice-rich soils, fluming or other procedures will be used where they can be effective. When possible, routes for temporary diversions should be selected in areas without ice-rich soils. Optimal diversion locations are usually outside of the standard construction zone. Where the need for diversions can be anticipated, the general location and access will be shown on the final design.

11.3.4.2.2 Ditch Checks

Permanent ditch checks should be constructed of logs or riprap and filter fabric.

In general, checks are required within constructed ditches under the following conditions:

- Design slopes are unstable.
- Heavy sediment loads are expected.
- Other sediment trapping measures are precluded or impractical.
- High water velocities.

Allowable ditch check heights are four feet for free-draining granular fill with riprap armor, and two feet for log, straw bale, or other types.

11.3.4.2.3 Grading to Drain

Designing the grade of an area to drain in a desired direction will be used where beneficial results are anticipated. This method will generally be used on large disturbed areas or embankments to direct surface waters onto areas or into structures where sedimentation control can be accomplished before being discharged into adjacent receiving waters. This grading may be designed in conjunction with ditches, channels, or levees to direct flow to the desired locations. Areas typically receiving this design are material sites, disposal sites, storage yards and facility pads.

11.3.4.2.4 Diversion Levees

Diversion levees are ridges or berms of soil that are used to divert and redirect flow away from disturbed areas or to prevent sediment-laden runoff from leaving disturbed areas untreated. The levees are designed with sufficient grade to provide drainage to an acceptable outlet or treatment device.

Levees will be considered:

- Where sheet flow is to be intercepted and the use of a ditch is not practical.
- Above cut slopes, to intercept excessive sheet flow runoff from upland areas and to divert the runoff away from the exposed slopes to acceptable outlets.
- Below fill slopes to prevent sediment-laden runoff from leaving the disturbed areas untreated.
- Across disturbed areas to shorten the length of exposed slopes, thereby reducing the potential for sheet and rill erosion, and diverting the sediment-laden runoff to a sediment basin or other treatment measure.
- Along the perimeter of a disturbed area to minimize the inflow of offsite sheet flow runoff and to prevent sediment-laden runoff from leaving the disturbed area untreated.
- Where the disturbance of ice-rich soils by drainage ditches would otherwise increase the potential for thermal erosion.
- Diversion levees may be designed above ablating slopes on a site-specific basis.

Information required for the hydraulic design of diversion levees will include:

- A measurement of the longitudinal slope of the natural ground.
- A measurement of the cross slope of the natural ground.
- The roughness factor and allowable velocity for natural ground and vegetation cover and the levee material.
- A measurement of the side slope of the levee.
- The type and quantity of flow expected.

A cross drainage (or relief) structure will be required whenever the incoming design flow is equal to levee capacity. Levee capacity is reached when flow depth equals 50% of levee height.

11.3.4.2.5 Water Bars

Water bars are shallow levees placed transversely across the workpad or other embankment to protect the graded surface iron erosion by sheet flow. The bars will be skewed to the workpad centerline to divert the runoff from the workpad to an acceptable outlet. Zigzag patterns for water bars will be considered if it is determined such a design will increase their effectiveness on a site-specific basis. Erosion at the ends of water bars will be controlled through the use of letdown structures or other methods outlined in this section. Water bars will generally be required:

- On erodible workpad materials.
- On workpads with steep longitudinal slopes.

Water bar spacing will be designed based on the slope of the workpad. Spacing may be decreased in the field depending upon location, soil type and embankment slope. Water bars will be placed, in general, as part of restoration. Water bars will not be used during construction except where required on a site-specific basis.

11.3.4.2.6 Letdown Structures

Letdown structures are lined or manufactured channels used to safely convey diverted surface runoff from the top to the bottom of disturbed slopes without causing erosion. The structures are generally required:

- At the outlet end of diversion levees above cut slopes.
- At the outlet end of diversion levees above erodible slopes or other sensitive areas.
- At the outlet end of perched relief low water crossings or culverts.

Letdown structures will not to be used for fish passage culverts.

A plunge basin or riprap apron will normally be required at the downstream end of any letdown structure. An appropriate channel size and channel liner will be determined using the design flow and velocity.

11.3.4.2.7 Channel Liners

Channel liners will be used to protect drainage ditches from erosion. Liners will be required wherever design flood velocities within drainages exceed maximum allowable velocities. Continuous lining may be required to protect drainage ditches with steep slopes.

11.3.4.2.8 Temporary Seeding

Annual ryegrass will be used independently as a temporary measure for erosion control where rapid cover is desired to prevent or reduce erosion. Annual ryegrass is fast growing, has an extensive root system, high seeding vigor and is acid soil tolerant. It will be applied independently of other species and will provide a high biomass with a high percent of cover and substantial height during the first year of growth. Since ryegrass is annual, it will only be used for temporary control.

The decision to use temporary seeding will be based on slope grade and length, soil type, soil thermal condition, and time of year. Generally the areas requiring temporary seeding will be surface disturbed areas as well as cut and fill slopes in soil types susceptible to hydraulic or wind erosion.

Where it is determined that disturbed areas have the potential for erosion or the construction zone has a longitudinal slope of such a magnitude as to promote longitudinal erosion, temporary seeding may be required for erosion control. For slopes less than 500 feet long, the following guidelines will be used:

- For the least stable soil type, slopes steeper than 5 percent will require temporary seeding.
- For the most stable soil type, slopes steeper than 15 percent will require temporary seeding.

For slopes more than 500 feet long, the following procedure will be used:

- Find disturbed surface area between top and bottom of slope and establish runoff.
- Find maximum velocity along the slope by using Manning's equation. Use Manning's equation, for very wide channels.
- If velocity exceeds the erosive velocity for the soil type, temporary seeding will be required.

Consideration will be given to the fact that it takes longer to establish vegetation on north facing slopes.

Restoration grading (see Section 12) will be undertaken as soon as construction is completed or use of the site is no longer required.

Where construction and restoration schedules do not allow for optimum permanent seeding times, temporary seeding will be used as an interim measure to provide protection. Temporary covers used in conjunction with temporary or permanent seeding will be used, for short periods if construction will temporarily eliminate the effectiveness of seeding.

Seasonal restoration schedules will ensure maximum use of the growing season, take maximum advantage of available moisture, and minimize winterkill. In order to do this, dormant seeding may be used. Dormant seeding will be accomplished after the first killing frost, which allows the seeds to take full advantage of available moisture during the following spring melt and runoff.

For additional details on seeding, see Environmental Information Supplement, Restoration.

11.3.4.3 Sedimentation Control Measures

11.3.4.3.1 Percolation Ponds

Percolation ponds are the most practical and least disturbing method of reducing suspended solids in water to meet the State Water Quality Standards. However, application of this technique is limited to areas where adequate soil percolation is possible, and overland discharge is not environmentally acceptable.

For small short duration discharges the pond areas will not require excavation or berms. Discharges will be on gravelly areas so that discharge flows do not reach receiving waters before suspended solids have been reduced to acceptable limits.

As discharge loads and durations increase, the pond may require excavation and/or berms to assure that there is no discharge flow to adjacent receiving water before reduction of suspended solids to acceptable limits.

The decision on whether or not to remove deposited suspended solids from water destined for floodplains will be based on the potentially deposited amounts and the relative increase this provides to the normal deposition characteristics of the floodplain. If there are other frequent silt deposits of comparable size in the floodplain, then the introduced deposit will be left untreated. Generally, deposits less than two inches deep and one acre in area will be left untreated.

The final design will include probable areas where these measures may be employed and it will delineate the necessary construction zone width. Proposed access, if necessary, will also be shown.

Operations, such as wet processing, where duration of discharge and expected solids can be estimated, will be detailed in the material site plans. The number of ponds will be planned and contingencies shown for additional ponds if area extent is not a constraint. If area extent is a constraint, provisions for pond clean out will be shown.

The disposition of deposited solids from wet processing operations will be determined based on site-specific conditions.

11.3.4.3.2 Silt Fences

Silt fences are permeable barriers used to remove sediment from sheet flow runoff. The fences are generally constructed of filter fabric backed by wire fencing. The fences may not be employed across streams, channels, or other locations where concentrated flows occur or may be anticipated. Silt fences are temporary measures and generally are required along the perimeter of disturbed areas to prevent sediment-laden sheet flow runoff from leaving the disturbed area untreated.

11.3.4.3.3 Sediment Filters

Sediment filters are low weirs constructed of free-draining material and they contain filter fabric. The structures may be used to provide a protected outlet for a diversion levee, to diffuse concentrated flows, to prevent ponding behind a levee, and to trap sediment in streams or constructed ditches. The structures are generally required:

- Across streams or constructed ditches where heavy sediment loads are anticipated and other treatment measures are not practical.
- Within diversion levees where there is a need to dispose of runoff at a protected outlet, or to diffuse concentrated flows.
- While not for use in fish bearing streams, sediment filters may be used in portions of an active floodplain or other areas associated with a fish bearing stream.

11.3.4.3.4 Sediment Basins

The sediment basin design methodology presented in this section applies to basins placed below broad areas of disturbance subject to sheet flow. Sediment basins may also be used to improve the quality of silty water collected in a concentrated flow, such as ditch water or sediment laden wash-water from gravel processing. These other basin usage will be covered in the project drainage and erosion control specification. Due to cost, land requirements and environmental concerns associated with excessive land disturbances, sediment basins will be considered where site specific conditions preclude the installation of other erosion and sediment control measures. Basins are used primarily to remove suspended solids and have only marginal effect in reducing turbidity.

- Basins will be located to:
  - Maximize storage benefit from the terrain.
  - Maximize ease of clean out.
  - Minimize disturbance to existing vegetation.
  - Minimize interference with construction activities.
- Sediment basin design will be based on the settling properties of the suspended solids and the basin's impact on the environment. The design will be developed in accordance with all applicable regulatory agency regulations and guidelines.

  – Additional volume will be provided to allow storage capacity consistent with the intended service life of the basin, the expected deposition rate and the practicality of clean out (especially as regards subsequent equipment access). In no case shall the sediment level be permitted to build up above the maximum settling depth.

  – The shape of the basin will be such that the effective flow length is equal to at least two times the effective flow width. The shape may be attained by selecting the basin site and by excavating to the desired shape. Installation of one or more baffles will increase the effective surface area of the basin.

  – Design the spillway to allow the design flood to pass. (5 years for temporary structures, 50 years for permanent).

  – The outlet from the spillway will provide a means of conveying the discharge in a non-erosive manner to an exiting drainage. Protection against scour at the outlet may be required.

  – The embankment will be designed on a site-specific basis. Such design will consider the structural integrity of the embankment.

  – Points of entrance of surface runoff into excavated basins will be appropriately protected to prevent erosion. Measures will be installed as required to ensure maximum travel distance of entering runoff to the outlet of the basin.

11.3.4.3.5 Recycle Pond

A recycle pond will be used if continued water use is necessary and:

- Water withdrawal is restricted.
- Area for treatment of discharge is restricted.
- The construction process involved can allow use of silty water.

The most likely application for recycle ponds will be as a water source for wet processing. Water withdrawal must be taken from a small fish bearing stream during low flow periods, or where it is determined that adjacent areas are unsuitable for other methods of sedimentation control.

Recycle pond needs will be identified and the ponds will be designed. Clean-out provisions will be included where calculations indicate accumulated sediments will exceed treatment capacity. The preferred provision is tandem ponds where one can be used while the other is being cleaned out. Final disposition of accumulated sediment will be determined on a site-specific basis.

11.3.5 Thermal Erosion Control Design

The preferred method of controlling thermal erosion is by selecting measures and designs which minimize or eliminate the thawing of thaw unstable soils. Such designs as thermal workpad embankments rather than cut sections will be initially considered. However, should a cut section be required, and after a terrain stability assessment it is determined that mitigation methods will not be adequate to prevent adverse impact to third party facilities, the environment or to the integrity of the gas pipeline, an adjustment to the alignment will be considered.

The terrain stability assessment of cuts in the construction zone will be based on the criteria and procedures defined during final design. Thaw penetrations allowed on frozen slopes and for cut sections will be developed as the terrain stability assessment is performed.

All designs for the control of thermal erosion in thaw unstable soils will be on a site-specific basis. Such designs will consider the following:

- Controlled Ablation

  Initial control of thermal erosion on cut slopes will consist of cutting the slope at a ratio of 1/4:1 and hand clearing the area far enough above the slope to allow controlled ablation of the slope. All slash and timber will be removed from the cleared area in order to minimize the tearing of the organic mat.

  The organic mat will drape over the face of the slope as the cut degrades which will shade and insulate the face. The mat will be reinforced with biodegradable netting if necessary to prevent tearing of the mat. No netting of any kind will be used in fish bearing streams. Diversion levees may be designed above ablating slopes on a site-specific basis.

Ditch checks may be required to retain mineral soil at the toe of cut faces. Meltwater will be controlled so as to minimize adverse effects of siltation.

- Gravel Buttresses

  Gravel Buttresses may be used to control thawing of cut slopes in fine-grained permafrost soils that will not self-stabilize. A buttress is placed at a finished slope of 1-1/2:1. The cut slope will be no steeper than 1/2:1 to be consistent with the structural and thermal requirements. The top of the buttress should generally be a minimum of two feet wide.

- Insulated Thermal Blankets

  Insulated thermal blankets may be used on cut slopes in fine-grained permafrost soils that will not self-stabilize. This method may also be used on cuts through fine-grained permafrost soils where slope height and gravel availability make gravel buttresses impractical.

- Adjacent Facilities

  Thermal and hydraulic erosion will be evaluated for potential adverse impact to third party facilities and structures. Potential headward erosion of drainages will be evaluated during field reconnaissance and design. Design measures will be provided as required and monitoring will be conducted during construction and operations.

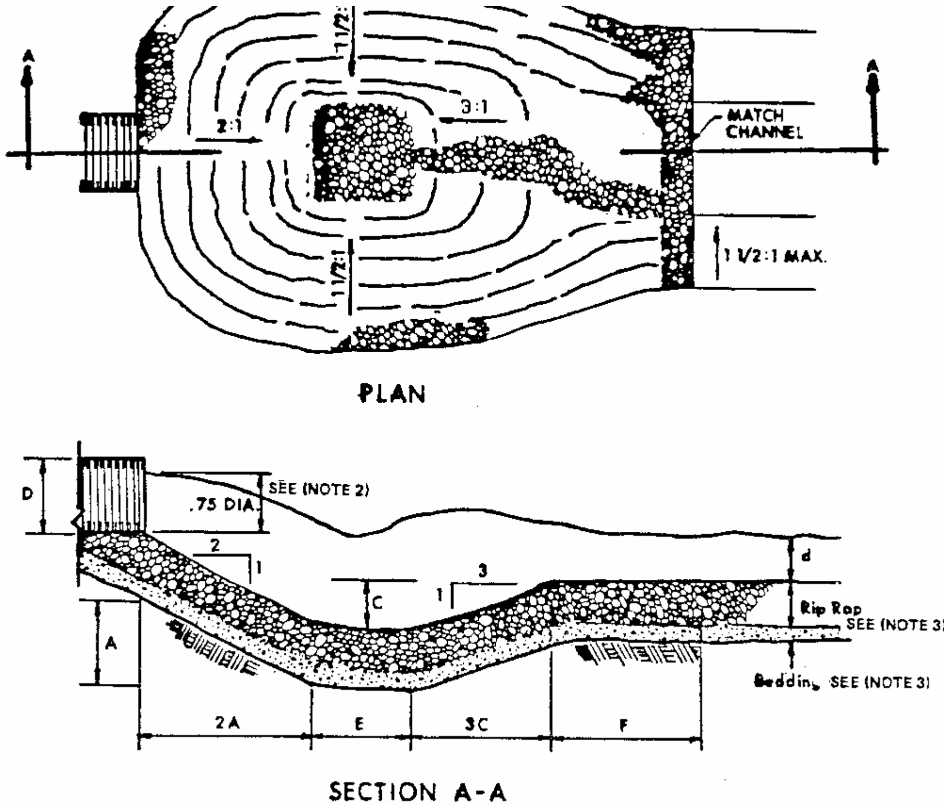

Figure 11-1 Typical Plunge Basin

1. *Where plunge basin is used for a culvert, use pipe diameter or span. Where plunge basin is used for a channel or letdown structure, use inlet channel bottom width.*
2. *Where plunge basin is used for a culvert, use 0.75 of pipe diameter or rise. Where plunge basin is used for a channel or letdown structure, use inlet channel design depth.*
3. *Riprap and bedding will be designed as specified in Section 16.*

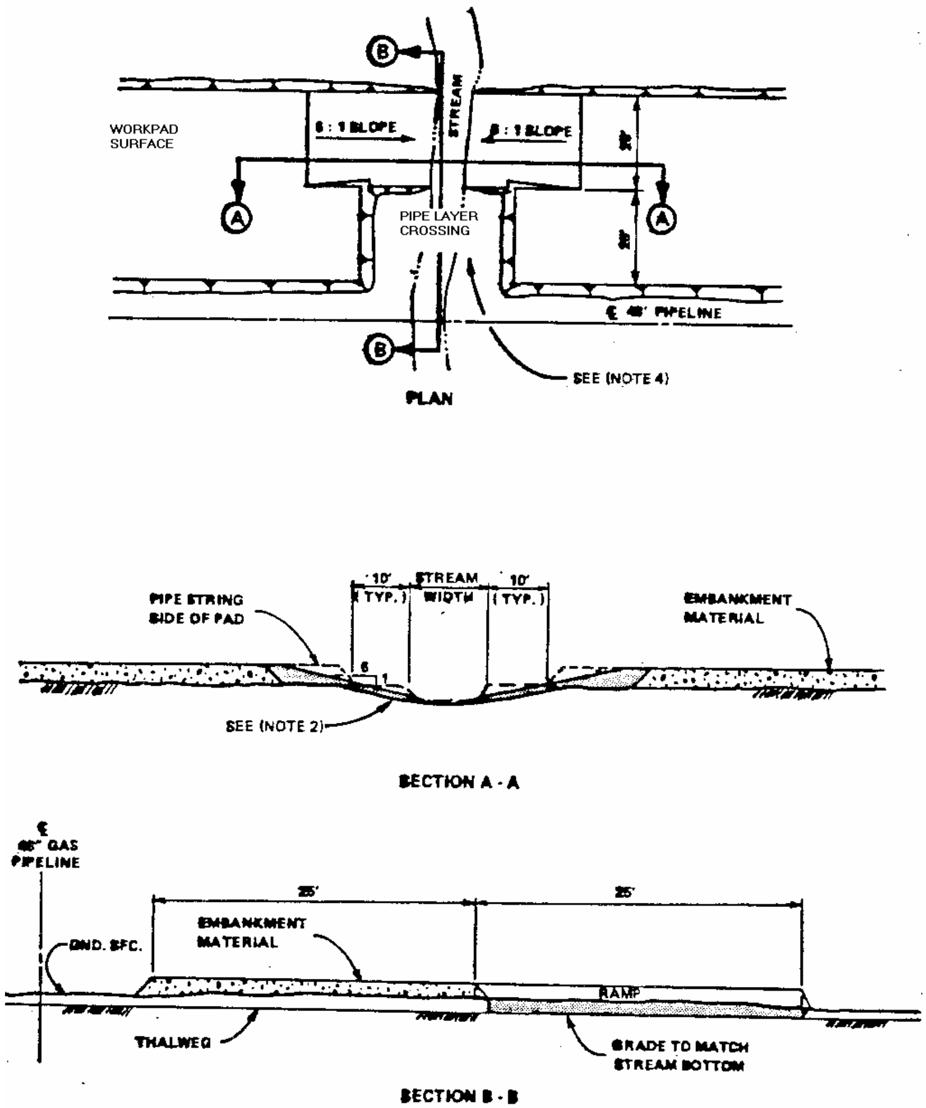

Figure 11-2 Typical Type I Low Water Crossing

Notes:

1. *Natural stream elevation, slope, and width will be maintained through crossing as practical.*
2. *Only one traffic area will be provided.*
3. *Material will be graded and angular.*
4. *Flexible mats or other protective devices will be used for streambank, bed, and vegetation depending upon season of construction and site specific conditions.*

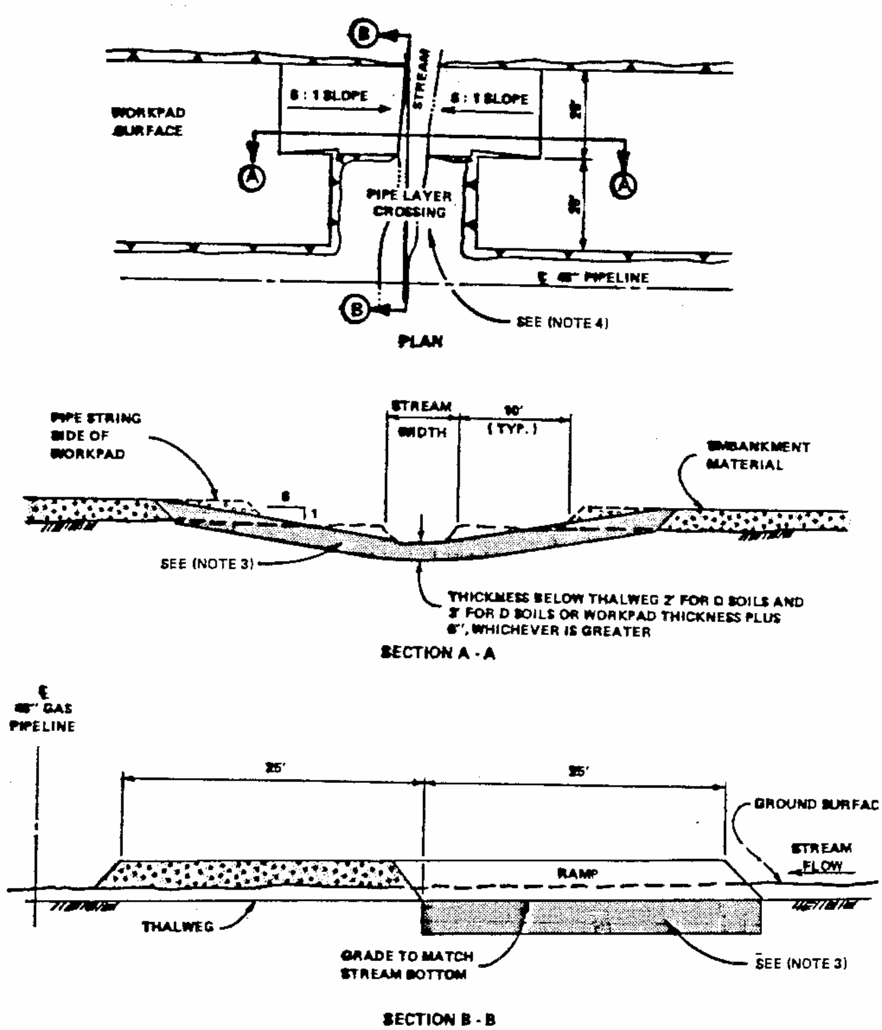

Figure 11-3 Typical Type II Low Water Crossing

Notes:

1. *Natural stream elevation, slope, and width will be maintained through crossing as practical.*
2. *Only one traffic area will be provided.*
3. *Material will be graded and angular.*
4. *Flexible mats or other protective devices will be used for streambank, bed, and vegetation depending upon season of construction and site specific conditions.*

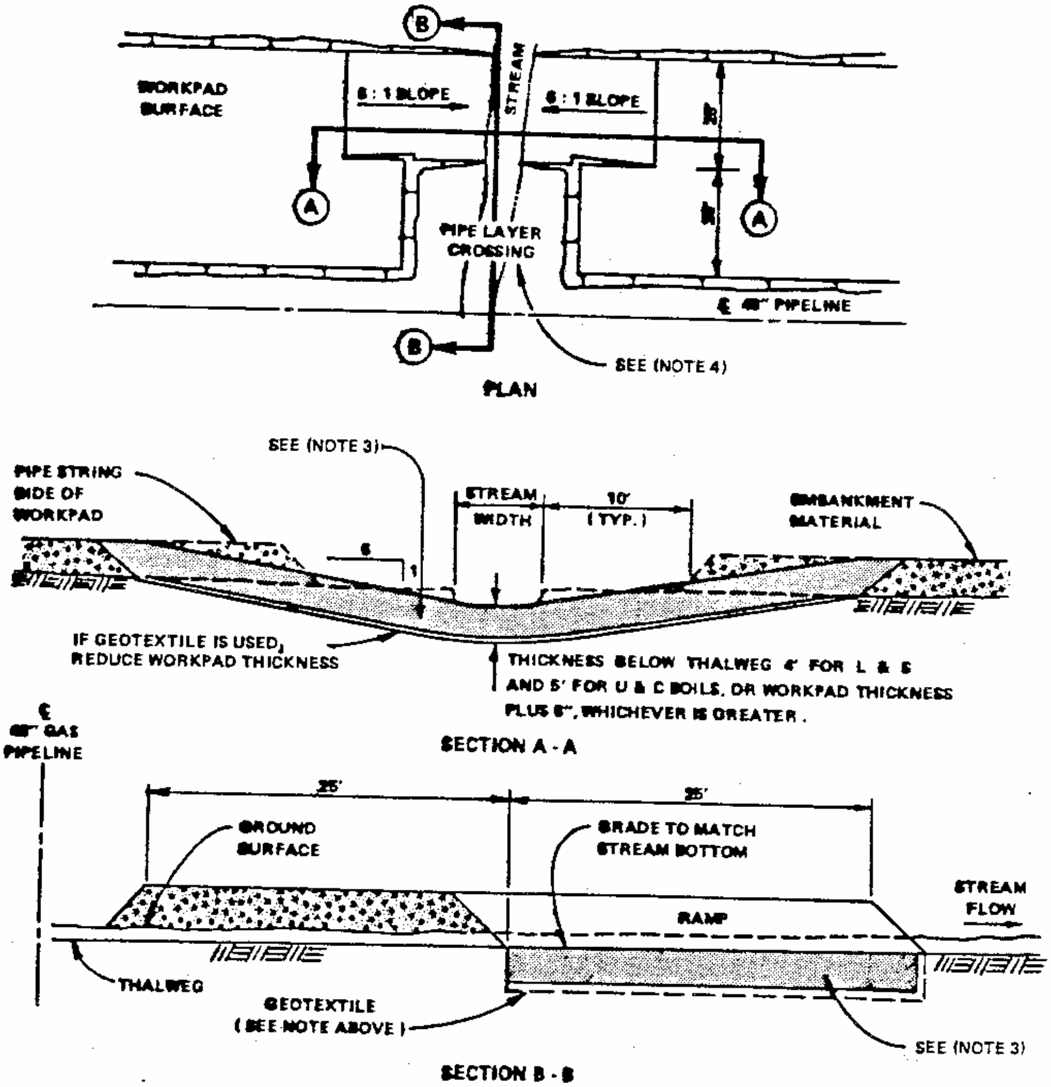

Figure 11-4 Typical Type III Low Water Crossing

Notes:
1. *Natural stream elevation, slope, and width will be maintained through crossing as practical.*
2. *Only one traffic area will be provided.*
3. *Material will be graded and angular.*
4. *Flexible mats or other protective devices will be used for streambank, bed, and vegetation depending upon season of construction and site specific conditions.*

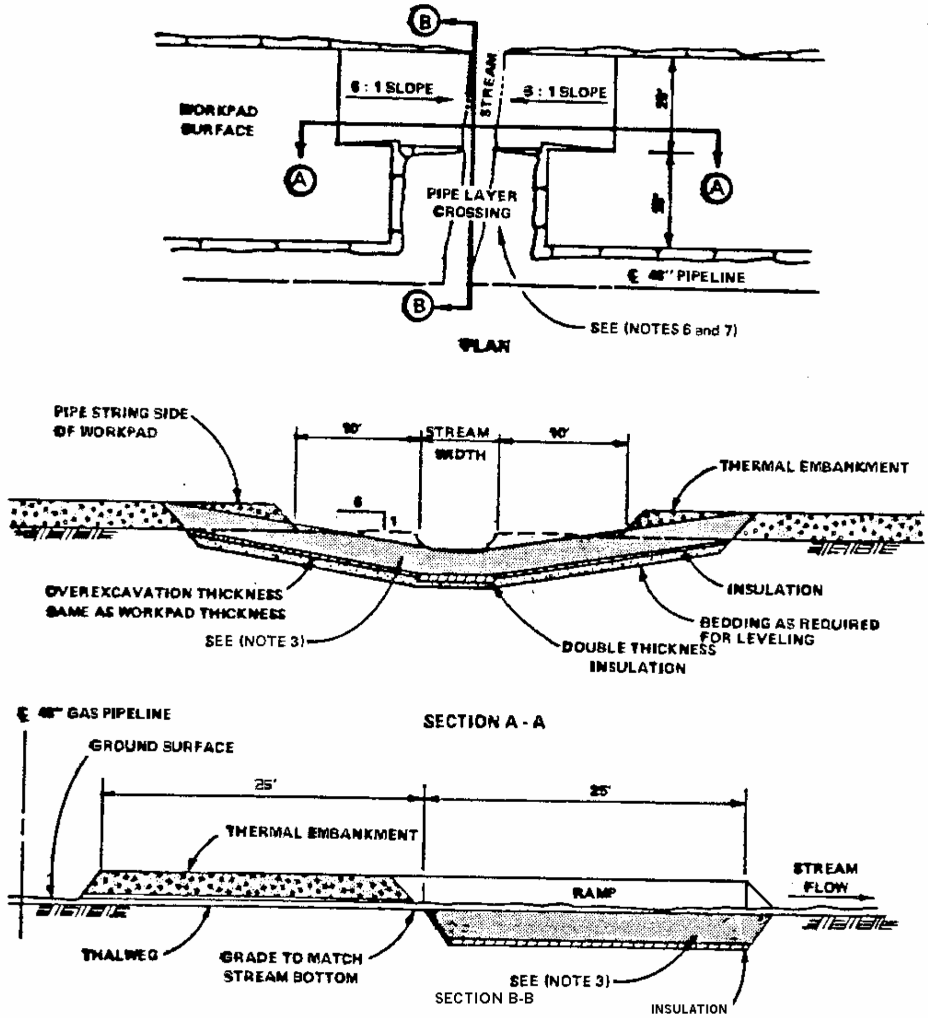

Figure 11-5 Typical Type IV Low Water Crossing
(All soils requiring thermal design)

Notes:

1. *Natural stream elevation, slope, and width will be maintained through crossing as practical.*
2. *Only one traffic area will be provided.*
3. *Material will be graded and angular.*
4. *Construction will occur after freezeback of the active layer*
5. *Insulation will be designed to limit 3-year thaw to the bottom of the insulation*
6. *Pipeline construction during shoulder months or use structural support as required.*
7. *Flexible mats or other protective devices will be used for streambank, bed, and vegetation depending upon season of construction and site specific conditions.*

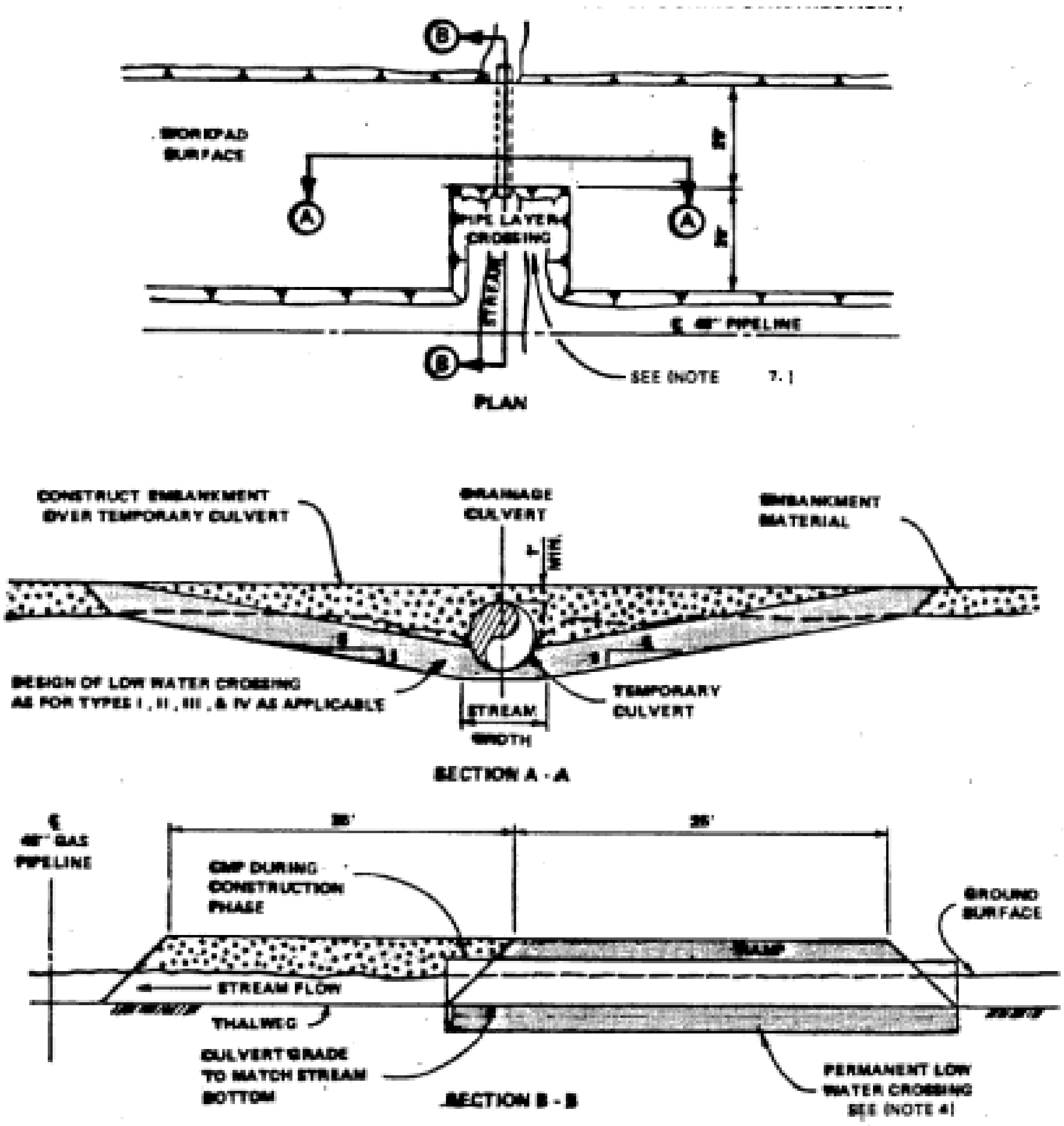

Figure 11-6 Typical Type IA, IIA, IIIA or IVA Low Water Crossing (Where crossing access is required during construction)

Notes:

1. *LWC with temporary culvert is designated as Type IA, IIA, IIA, or IVA depending on Low Water Crossing requirements (See Figures on Type I, II, III, or IV)*
2. *Natural stream elevation, slope, and width will be maintained through crossing as practical.*
3. *Only one traffic area will be provided.*
4. *Material will be graded and angular.*
5. *In fish streams, the culvert invert will be at a depth equal to 20% of the culvert diameter below the thalweg.*
6. *In fish streams, after temporary culverts are removed, the thalweg will be reconnected to maintain a minimum 6" depth for the 2-year flow.*
7. *Flexible mats or other protective devices will be used for streambank, bed, and vegetation depending upon season of construction and site specific conditions.*

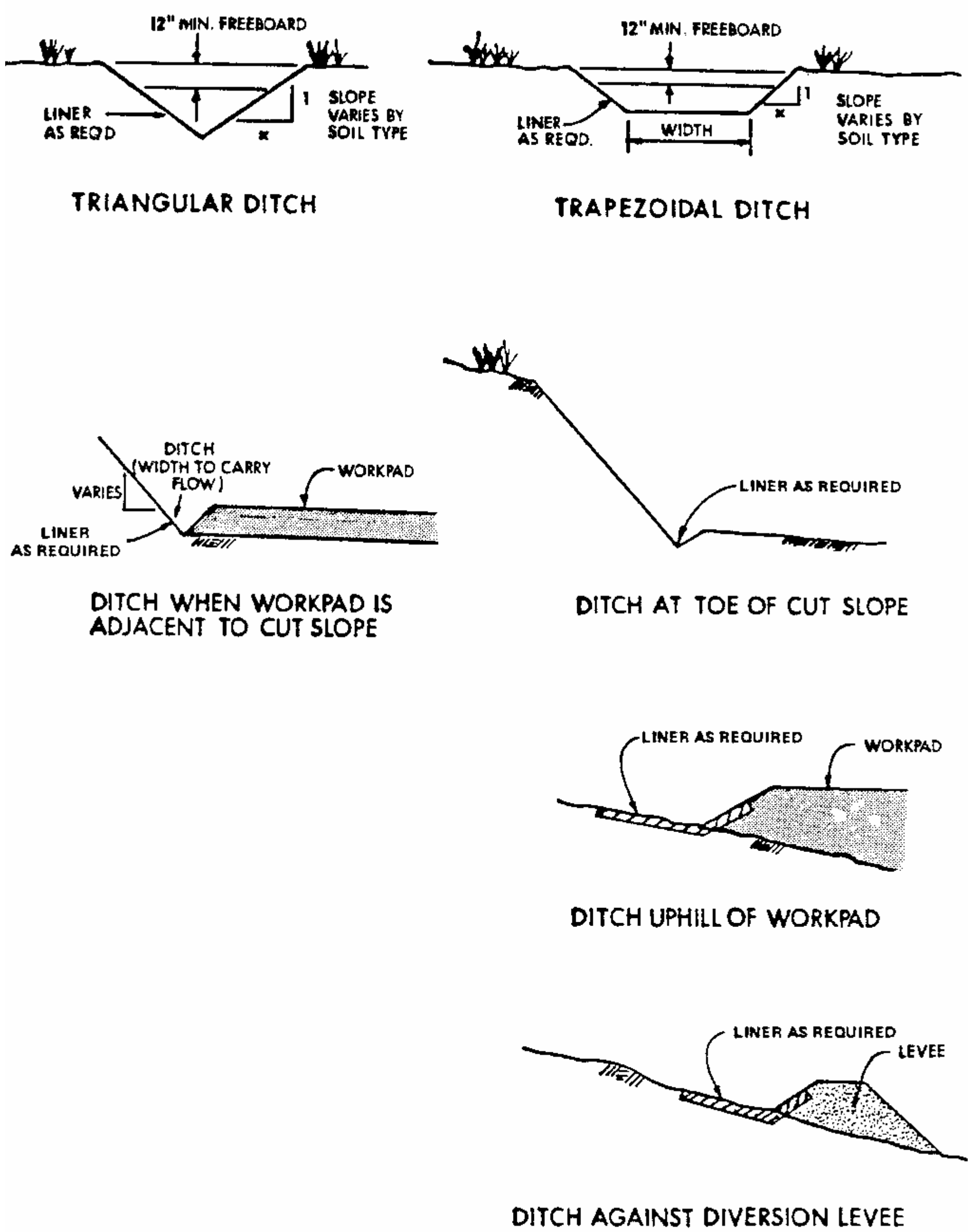

Figure 11-7 Typical Drainage Ditch Design